CLAIMS

We claim:

1. An abrasive, fluid jet cutting apparatus comprising:

a chamber having an inlet for receiving a pressurized fluid jet, a port for receiving a flow of abrasive particles which are entrained into said fluid jet, and an exit through which said fluid jet and entrained abrasives exit said chamber,

a mixing tube having an entry port for receiving said fluid jet and entrained abrasives, an inner wall for directing the flow of said fluid jet and entrained abrasives, and an outlet port through which said fluid jet and entrained abrasives exit said tube, wherein said tube entry port is proximate said chamber exit,

a lubricating fluid reservoir that surrounds at least a portion of the outer wall of said mixing tube,

wherein at least a portion of said mixing tube wall being porous, and

wherein said lubricating fluid passes from said lubricating reservoir and through said porous wall to lubricate at least a portion of the surface of said mixing tube wall so as to resist erosion of said tube wall while the fluid jet and entrained abrasives flow through said mixing tube.

2. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports is in the range of 50-3,000 microns.

3. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said abrasive particles have an average diameter of less than half of the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports.

4. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said lubricating fluid having a kinematic viscosity whose ratio with the kinematic viscosity of said jet's carrier fluid is in the range of 100/1 – 40,000/1.

5. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said lubricating fluid has a flow rate whose ratio with the flow rate of the fluid jet and entrained abrasives is in the range of 1/10,000 – 1/20.

6. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein the thickness of said mixing tube wall is varied along its length to control the flow rate of the lubricating fluid.

7. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said mixing tube wall has variable porosity along its length to control the flow rate of the lubricating fluid.

8. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said porous mixing tube being fabricated from a porous ceramic material.

9. An abrasive, fluid jet cutting apparatus as recited in claim 8, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous ceramic material.

10. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said porous mixing tube being fabricated from a porous metal.

11. An abrasive, fluid jet cutting apparatus as recited in claim 10, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous metal.

12. An abrasive, fluid jet cutting apparatus as recited in claim 1, wherein said porous mixing tube being fabricated from a gravity sintered, porous material.

13. An abrasive, fluid jet cutting apparatus as recited in claim 12, wherein the mixing tube passage connecting its inlet and outlet ports is made by using electric discharge machining to machine said porous material.

14. A method for reducing erosion on the inner wall of a cutting jet, mixing tube due to a fluid jet with entrained abrasive particles flowing from said tube's inlet port, along said tube's wall and exiting through said tube's outlet port, said method comprises the steps of:

forming said mixing tube so that at least a portion of its wall is porous,

surrounding at least a portion of the outer wall of said mixing tube wall with a lubricating fluid reservoir, and

forcing lubricating fluid to pass from said lubricating reservoir and through said porous wall to form a lubricating film between said mixing tube wall and said flow of abrasive fluid.

15. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports is in the range of 50-3,000 microns.

16. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said abrasive particles have an average diameter of less than half of the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports.

17. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said lubricating fluid having a kinematic viscosity whose ratio with the kinematic viscosity of said jet's carrier fluid is in the range of 100/1 – 40,000/1.

18. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said lubricating fluid has a flow rate whose ratio with the flow rate of the fluid jet and entrained abrasives is in the range of 1/10,000 – 1/20.

19. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein the thickness of said mixing tube wall is varied along its length to control the flow rate of the lubricating fluid.

20. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said mixing tube wall has variable porosity along its length to control the flow rate of said lubricating fluid.

21. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said porous mixing tube being fabricated from a porous ceramic material.

22. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 21, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous ceramic material.

23. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said porous mixing tube being fabricated from a porous metal.

24. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 23, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous metal.

25. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 14, wherein said porous mixing tube being fabricated from a gravity sintered, porous material.

26. A method for reducing erosion on the inner wall of said mixing tube as recited in claim 25, wherein the mixing tube passage connecting its inlet and outlet ports is made by using electric discharge machining to machine said porous material.

27. A mixing tube apparatus for use with an abrasive, fluid jet cutting system, said system comprising a chamber having an inlet for receiving a pressurized fluid jet, a port for receiving a flow of abrasive particles which are entrained into said fluid jet, and an exit through which said fluid jet and entrained abrasives exit said chamber, wherein said mixing tube apparatus comprising:

a mixing tube having an entry port for receiving said fluid jet and entrained abrasives, an inner wall for directing the flow of said fluid jet and entrained abrasives, and an outlet port through which said fluid jet and entrained abrasives exit said tube, wherein said tube entry port is fixed proximate said chamber exit,

a lubricating fluid reservoir that surrounds at least a portion of the outer wall of said mixing tube,

wherein at least a portion of said mixing tube wall being porous, and

wherein said lubricating fluid passes from said lubricating reservoir and through said porous wall to lubricate at least a portion of the surface of said mixing tube wall so as to resist erosion of said tube wall while the fluid jet and entrained abrasives flow through said mixing tube.

28. A mixing tube apparatus as recited in claim 27, wherein the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports is in the range of 50-3,000 microns.

29. A mixing tube apparatus as recited in claim 27, wherein said abrasive particles have an average diameter of less than half of the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports.

30. A mixing tube apparatus as recited in claim 27, wherein said lubricating fluid having a kinematic viscosity whose ratio with the kinematic viscosity of said jet's carrier fluid is in the range of 100/1 – 40,000/1.

31. A mixing tube apparatus as recited in claim 27, wherein said lubricating fluid has a flow rate whose ratio with the flow rate of the fluid jet and entrained abrasives is in the range of 1/10,000 – 1/20.

32. A mixing tube apparatus as recited in claim 27, wherein the thickness of said mixing tube wall is varied along its length to control the flow rate of the lubricating fluid.

33. A mixing tube apparatus as recited in claim 27, wherein said mixing tube wall has variable porosity along its length to control the flow rate of the lubricating fluid.

34. A mixing tube apparatus as recited in claim 27, wherein said porous mixing tube being fabricated from a porous ceramic material.

35. A mixing tube apparatus as recited in claim 34, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous ceramic material.

36. A mixing tube apparatus as recited in claim 27, wherein said porous mixing tube being fabricated from a porous metal.

37. A mixing tube apparatus as recited in claim 36, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous metal.

38. A mixing tube apparatus as recited in claim 27, wherein said porous mixing tube being fabricated from a gravity sintered, porous material.

39. A mixing tube apparatus as recited in claim 38, wherein the mixing tube passage connecting its inlet and outlet ports is made by using electric discharge machining to machine said porous material.

40. A mixing tube for use with an abrasive, fluid jet cutting system, said system comprising a chamber having an inlet for receiving a pressurized fluid jet, a port for receiving a flow of abrasive particles which are entrained into said fluid jet, and an exit through which said fluid jet and entrained abrasives exit said chamber, wherein said mixing tube having:

an entry port for receiving said fluid jet and entrained abrasives, an inner wall for directing the flow of said fluid jet and entrained abrasives, and an outlet port through which said fluid jet and entrained abrasives exit said tube, wherein said tube entry port is fixed proximate said chamber exit,

wherein at least a portion of said mixing tube wall being porous,

wherein at least a portion of said mixing tube when in use being surrounded by a lubricating fluid reservoir, and

wherein said lubricating fluid passes from said lubricating reservoir and through said porous wall to lubricate at least a portion of the surface of said mixing tube wall so as to resist erosion of said tube wall while the fluid jet and entrained abrasives flow through said mixing tube.

41. A mixing tube as recited in claim 40, wherein the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports is in the range of 50-3,000 microns.

42. A mixing tube as recited in claim 40, wherein said abrasive particles have an average diameter of less than half of the smallest cross sectional dimension of the passage connecting said mixing tube inlet and outlet ports.

43. A mixing tube as recited in claim 40, wherein said lubricating fluid having a kinematic viscosity whose ratio with the kinematic viscosity of said jet's carrier fluid is in the range of 100/1 – 40,000/1.

44. A mixing tube as recited in claim 40, wherein said lubricating fluid has a flow rate whose ratio with the flow rate of the fluid jet and entrained abrasives is in the range of 1/10,000 – 1/20.

45. A mixing tube as recited in claim 40, wherein the thickness of said mixing tube wall is varied along its length to control the flow rate of the lubricating fluid.

46. A mixing tube as recited in claim 40, wherein said mixing tube wall has variable porosity along its length to control the flow rate of the lubricating fluid.

47. A mixing tube as recited in claim 40, wherein said porous mixing tube being fabricated from a porous ceramic material.

48. A mixing tube as recited in claim 47, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous ceramic material.

49. A mixing tube as recited in claim 40, wherein said porous mixing tube being fabricated from a porous metal.

50. A mixing tube as recited in claim 49, wherein the mixing tube passage connecting its inlet and outlet ports is made by a process selected from the group consisting of casting, molding and machining processes for said porous metal.

51. A mixing tube as recited in claim 40, wherein said porous mixing tube being fabricated from a gravity sintered, porous material.

52. A mixing tube as recited in claim 51, wherein the mixing tube passage connecting its inlet and outlet ports is made by using electric discharge machining to machine said porous material.